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INT CL[5] G01S 7/38 7/48 7/52, H04K 3/00

(54) Electronic counter-measures for towing by an aircraft

(57) A deception jamming device (R) is towed by a cable (CR) connected to an aircraft (A). A selected jamming signal is transmitted to the towed object (R) by means of at least one optical fibre incorporated in the cable (CR) and the jamming signal, which is prepared in the aircraft, is then transmitted by means of the towed object (R). Preferably the cable comprises one or more optical fibres with Peltier cooled receiver(s) and bifiler metalic links for feed currents and logic signals controlling electromagnetic and/or infra-red transmission from antenna on the front and rear of the object. The device which may employ turbines for power generation, may be recovered by rewinding the cable or jettisoned by guillotining. A braking parachute may be employed.

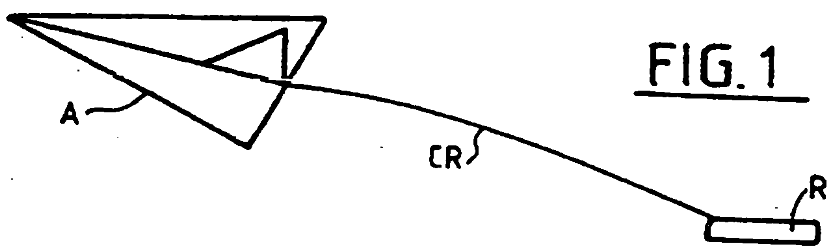

FIG. 1

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FIG. 1

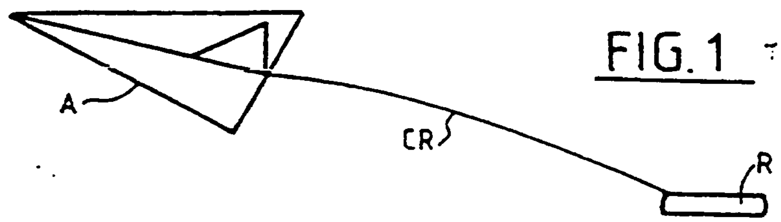
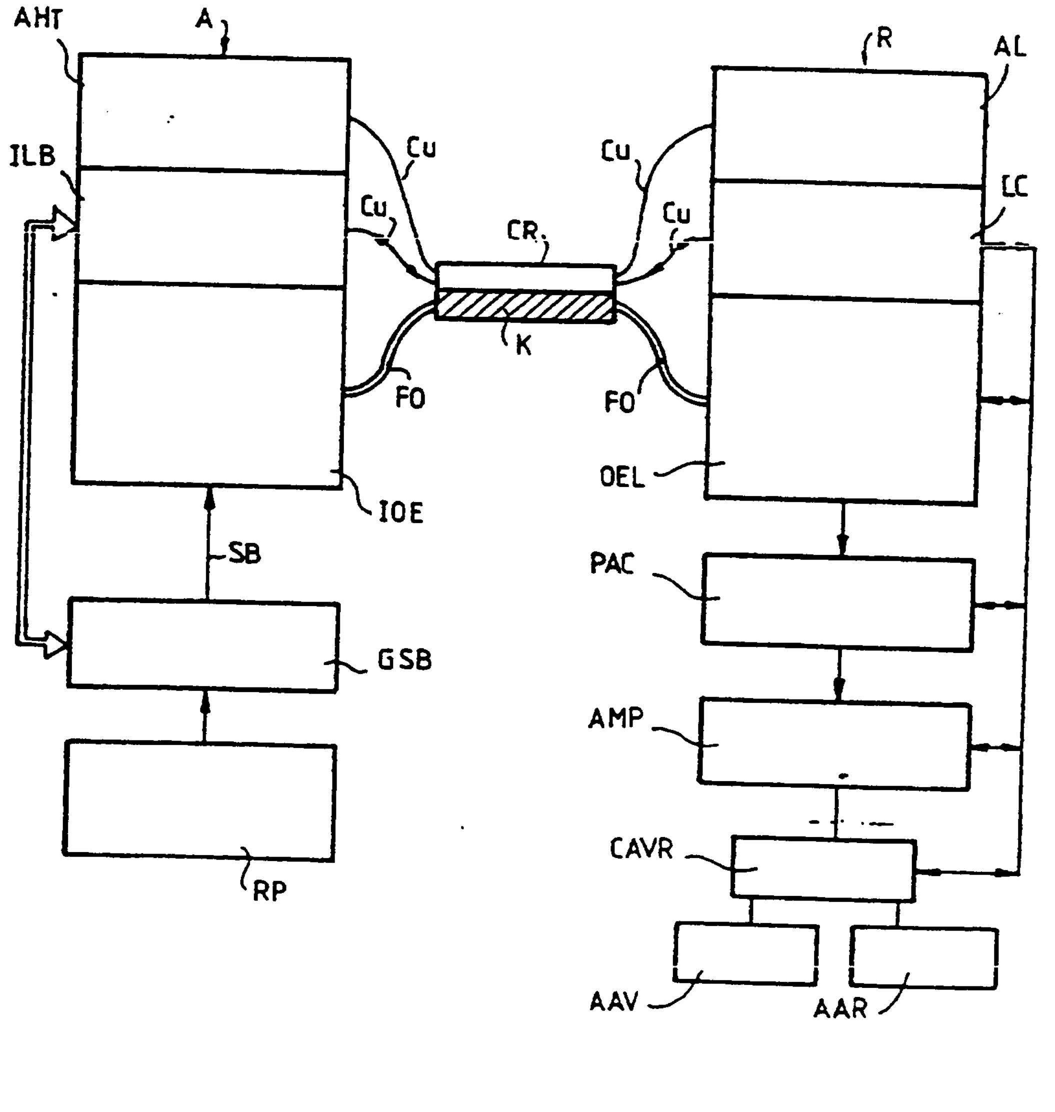

A
CR
R

FIG. 2


AHT
A
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CR
K
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FIG. 3

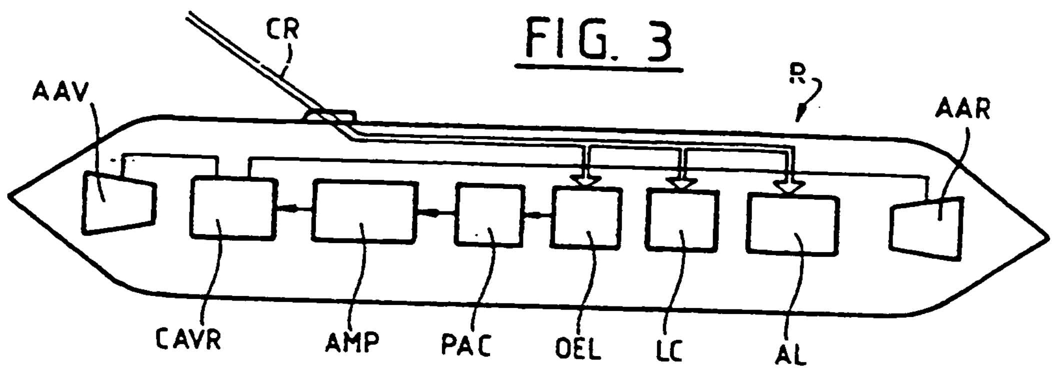


FIG. 4

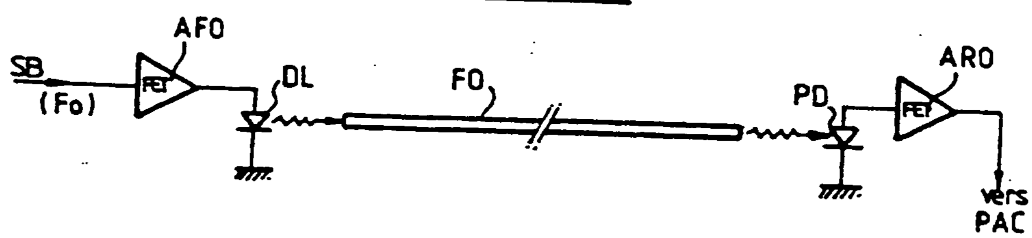
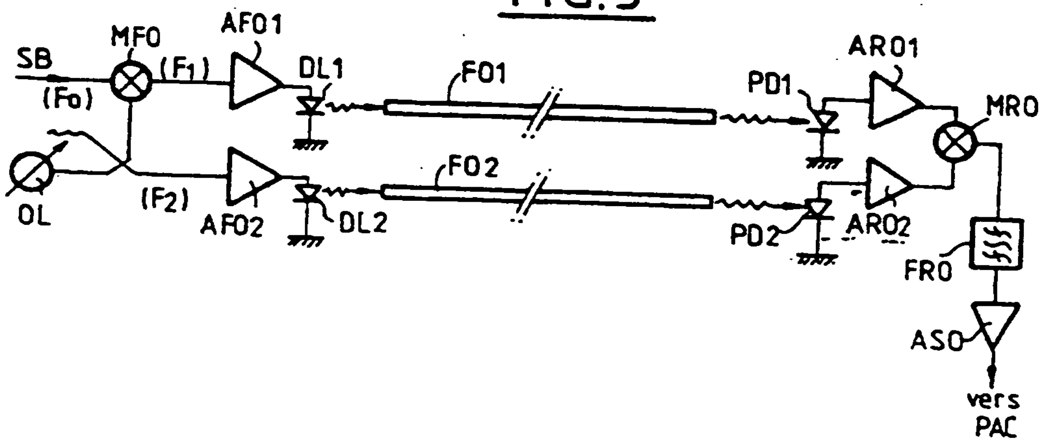


FIG. 5



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ELECTRONIC COUNTER-MEASURES METHOD AND APPARATUS FOR TOWING BY AN AIRCRAFT

The present invention concerns the technical domain of electromagnetic countermeasures, chiefly for aircraft.

Firstly it is known to carry out self-shielding jamming which calls for a single carrier, that is a single aircraft. In this case, the energy source of the jamming is necessarily confused with the carrier, which is therefore always sighted by the detectors of the threat. Of course, there are contrivances which help to simulate a false position of this single carrier, but the use of electronic counter-countermeasures very often allows these contrivances to be overcome. Thus, in order to put into operation an effective jamming, this jamming must be specific, that is the threat to be jammed must be known a priori. The person skilled in the art will understand that this complicates matters considerably.

One may also resort to decoys. Whether this involves conductive chaff, punctiform decoys, or (even better) active response decoys, these decoys suffer from diverse disadvantages. It will be sufficient to note here that they are, for the most part, detectable by means of electronic counter-countermeasures, which again reduces their effectiveness.

Another category of jamming is that of centroidal jamming. By using at least two aircraft one may attempt to introduce into the tracking window of the threat (distance and/or Doppler window) a signal which comes from another direction, for the purpose of superimposing this signal on the signal of the target in such a way that the resultant is in a third direction differing from the first two. There are different categories of this type of jamming. There are also variants which help to avoid the disadvantages of the tracking of the jamming itself ("homing on jamming"). But the principal disadvantage of these types of jamming is that they require at least two aircraft.

Moreover, in the case of watercraft, it has been

proposed to tow an active decoy in the direction of the arrival of the threat. It is difficult to transfer this solution to aircraft, since the decoy which is towed in this way would have to be capable of a certain degree of navigation, which renders its application in practice prohibitive.

Finally, it has also been proposed to connect a towed jamming device to an aircraft. In an autonomous manner, this towed jamming device can function as a responder or as a noise jammer. In the first case the jammer is generally only credible for continuous-wave sources or threats coming from behind. In the second case the device functions well but is extremely difficult to realize, taking into account the constraints of space requirements, the cost, the energy source, and climate control. The carrier aircraft or, more accurately, the towing aircraft, is considerably disadvantaged, since the permissible flight envelope is very restricted.

The present invention proposes another solution which is clearly more advantageous.

Accordingly a first aspect of the present invention provides an electromagnetic countermeasures method for aircraft, wherein an auxiliary towed jamming device is connected at least temporarily with an aircraft; a selected jamming signal is transmitted to said auxiliary device; and said selected jamming signal is transmitted by means of said auxiliary device.

Advantageously, the auxiliary device is fed by lines which are likewise connected with the towing cable, preferably by high-voltage, high-frequency lines.

Desirably, digital line links, particularly bi-directional links, may likewise be connected with the towing cable.

Specifically, the primary reception of the incident electromagnetic signals and the processing of the jamming signal are effected on board the aircraft, whereas the role of the auxiliary device is to transmit the jamming signal

which is obtained in this manner.

The invention likewise aims to provide an electromagnetic countermeasures device for aircraft. In a known manner, this device comprises a towed auxiliary device which can be deployed from the aircraft.

Accordingly a second aspect of the invention provides an electromagnetic countermeasures device for aircraft, comprising a towed auxiliary device which can be deployed from the aircraft, a towing cable equipped with at least one optical fibre, and means at the auxiliary device for the transmission of a jamming signal which is transmitted along said optical fibre.

The power supply, as well as the digital transmission, can be effected as previously indicated. Preferably, at the end of the towing cable nearer the towed auxiliary device, the optoelectronic receivers of the optical fibre or fibres are cooled, more preferably by means of cooling with the use of the Peltier effect.

The digital line connections can serve for the commutation between two transmitting jamming antennae arranged, respectively, under radomes at the front and back of the auxiliary device.

This auxiliary device may advantageously comprise a transmitting amplifier consisting of travelling-wave tubes which can function at a relatively high temperature and, consequently, do not necessitate sophisticated cooling mechanisms.

Suitably, two optical fibres may be connected with the towing cable for transmitting the jamming signal according to two portions of the useful frequency spectrum.

In order that the present invention may more readily be understood the following description is given, merely by way of example, with reference to the accompanying drawings, in which:-

FIGURE 1 shows, in a schematic presentation, an aircraft equipped with a towed auxiliary device;

FIGURE 2 is a basic wiring diagram of the elements located on board the aircraft and the auxiliary device for putting the invention into operation;

FIGURE 3 is a basic wiring diagram of the towed auxiliary device itself;

FIGURE 4 is a basic wiring diagram in the case of transmission through a single optical fibre; and

FIGURE 5 is a basic wiring diagram in the case of transmission through two optical fibres.

The Applicants have observed that, in general, the electronic countermeasures (ECM) device which is installed on board an aircraft has many qualities, chiefly with respect to the analysis of incident radioelectric signals and the possibility of generating sophisticated jamming. Taking into account present knowledge, the only deficiency of such an ECM device is that the transmitter radiating the energy is confused with the aircraft, resulting in the risk of a tracking of the jammer ("homing on the jammer").

Solutions which consist in illuminating a reflector by means of the jammer, in order to cause indirect jamming, are conceivable but their efficiency is extremely low.

On the contrary, the invention recommends that the transmitter be separate from the aircraft and towed behind it. An ultra high-frequency link transmits the jamming signal generated by the aircraft to this transmitter, and it is currently considered preferable to effect this transmission by means of optical fibres.

The towing distance, that is the length of the towing cable, must be appropriately selected. The towed auxiliary device must be close enough to the aircraft so that it can hardly be distinguished from it as seen by the threat. That is, the two objects must be located in the principal lobe of the antennae of this threat.

The towed device must also be far enough away from the aircraft so that the distance of passage of the threat heading toward the towed object is greater than the distance

triggering the proximity fuse, so that the aircraft is not endangered.

It is currently considered that this distance must be approximately between 100 and 200 meters.

The Applicants have also given considerable attention to the fact that the proposed system must remain operational, that is it must not disadvantage the aircraft, over its entire flight envelope.

As a result, the device must be light and small so as to have as little drag as possible. This presupposes that the towed object has a mass of a few kilograms and a volume of a few litres, and will be well streamlined.

It is also necessary that this towed object possess a low equivalent radar surface so as to avoid the triggering of proximity fuses when missiles carrying them pass by the vicinity of the object. It is also necessary to prevent an observing radar from detecting its presence; such information would be immediately usable for "cancelling" the towed object from the signals received by the threat.

It is currently considered that the towed object must be energised by the aircraft in such a way as to have a practically unlimited autonomy of operation. A variant would consist in providing an autonomous power feed by means of turbines, at the cost of problems with respect to the mounting of the antennae and also from the point of view of drag and of the equivalent radar surface, which would both be increased.

The towed object should be linked as discretely as possible with the aircraft. Taking into account the transmission losses occurring at a distance of 200 meters, which losses are not negligible, it is currently estimated that an antenna link lacks discretion because of the power required and in addition it complicates the compatibility of the towed object with the aircraft. For this reason it is currently preferred that the ultra high-frequency link be effected by means of light modulation by means of one or more optical

fibres, which constitutes a light and discrete link with very low losses.

Under these circumstances, a single cable can ensure the towing functions and the supply of power, of analog electric signals for jamming, and of digital control signals.

Figure 1 shows an aircraft A which pulls a towed auxiliary device R by means of a towing cable CR.

In practice, the auxiliary device R can be deployed in flight as soon as the presence of a threat has been logged. This auxiliary device can be brought back into the aircraft after use by means of rewinding the towing cable, at least for test applications or in peacetime. It can alternatively simply be abandoned after use.

In cases where it is conserved, the towed auxiliary device can also be released before landing, with aerodynamic braking by means of a parachute, and recovered on the runway.

In Figure 2, the portion on the left relates to an aircraft A, the portion on the right is concerned with the towed object R, and the construction of the towing cable CR can be seen between the latter.

The aircraft A is equipped with a primary receiver RP for detecting incident radioelectric signals relating to the threats. Based on this, a generator circuit GSB produces a jamming signal SB, as well as digital commands. The jamming signal SB is applied to an optoelectronic interface for analog jamming signals, designated IOE. The digital signals issuing from the circuit GSB are applied to a bidirectional logical interface ILB. Finally, a power supply AHT provides a high-voltage power current at a relatively high frequency, usually at least 10 kHz. The towing cable comprises a Kevlar (T.M.) traction portion, designated K. One or more optical fibres FO, which serve to transmit the jamming signal itself, are arranged around the latter. Bifilar metallic links, consisting, for example of copper, are also provided for transmitting, on the one hand, the bidirectional logic signals, and, on the other hand, the feed current.

At the other end, the feed current is recovered in a circuit AL which is incorporated in the towed auxiliary device R (see also Figure 3). This feed is connected to all of the internal circuits of the device R, by a link which, for the sake of simplifying the drawing, is not shown.

The pair issuing from the interface ILB of the aircraft is transmitted to a bidirectional logical interface which constitutes a portion of the control logic LC incorporated in the aircraft.

Finally, there is a connection from the at least one optical fibre FO to an optoelectronic interface OEL for the jamming signals.

The jamming signal is applied to a preamplifier and correcting device PAC, followed by a transmitting amplifier AMP , which advantageously consists of travelling-wave tubes, and, finally by an ultra high-frequency commutator CAVR.

The function of the commutator CAVR is to permit, in a controlled manner, the feed of either a front antenna AAV or a rear antenna AAR, both of which are incorporated under radomes of the towed device R.

The logic signals issuing from the device LC serve firstly to control the state of this commutator CAVR. In fact, according to what the aircraft detects, transmission will be effected in front of or behind the towed object.

The control logic LC can likewise ensure the test functions of the other elements of the towed object R, as shown by the links to the devices OEL, ACAMP and CAVR of Figure 2.

In Figure 4, the signal SB, having the frequency F_0, is assumed to occupy a spectrum which can be transmitted through a single optical fibre and with a single laser transmission diode.

Thus, this signal SB is applied to an amplifier AFO consisting, for example, of field-effect transistors for controlling a single laser diode DL, these field-effect

transistors being coupled at the input of an optical fibre FO. The output of this optical fibre is coupled with a photodetector PD which feeds another amplifier ARO, whose output can then be fed to the circuit PAC.

At the present time the components, shown in Figure 4, permitting the transmission, in a spectral band going from 6 to 18 gigahertz, are still difficult to use in large series.

For this reason, the assembly according to Figure 5 can be used if a wide transmission band is required.

The jamming signal SB is applied to a first mixer MFO which receives a local signal from an oscillator OL. A signal of frequency F_1 results, which is transmitted to an amplifier AF01, followed by a laser diode DL1 for transit through a first optical fibre FO1.

The local signal, having a frequency F_2, is transmitted through the amplifier AFO2 which excites the laser diode DL2 for transit through the fibre FO2.

The photodetectors PD1 and PD2 are located at the other ends of the two fibres, followed by respective amplifiers ARO1 and ARO2 whose outputs are mixed in a mixer MRO, followed by a filter FRO. This is followed by an output amplifier ASO which can supply the preamplifier PAC.

Of course, it will be necessary to effect spectral corrections, among others, which are carried out in the pre-amplifier circuit PAC.

It will be seen that the device just described has an angular coverage which is made as omnidirectional as possible because of the commutation between the front and rear antennae, which prevents the occurrence of transversely spaced discrete lobes resembling daisy petals.

Moreover, a great effectiveness is achieved in that the jamming signal emanates from the towing aircraft itself.

A variant of the invention appears here: if the towing aircraft is itself equipped for jamming in coordination with another aircraft, one or both of the towed devices can transmit the jamming signal relating to the other aircraft.

Moreover, by using an emulsion amplifier consisting of travelling-wave tubes, it is arranged that the operating temperature does not necessitate any climate control other than the exchange with the outer surface of the towed object R, this being necessary throughout the flight envelope.

It is advantageous that the transmitting antennae of the object R be capable of working in bipolarization, which allows the transmission to be obtained in the desired form and coverage.

In another arrangement, it is advantageous that the construction of the object R be airtight so as to conserve internal air pressure, which facilitates the realization of very high-voltage feeds, as well as the power response of the ultra high-frequency circuits and, particularly, the transmitting antennae.

The device which ensures the unwinding and possibly the rewinding of the cable has not been described here in detail. It is considered within the scope of the person skilled in the art; although it will be noted that some control must be provided for limiting the speed with which the cable is let out. In the same sense, a guillotine system will be provided for the emergency jettisoning of the towed object, particularly in real combat operations.

Of course, the same aircraft can also be equipped with a plurality of stored towed objects of this type which it can deploy one after the other.

It can also be provided that a plurality of towed objects, connected at different places along the cable, are towed by the same cable. This is of interest chiefly for large aircraft.

The use of the device, according to the invention, for countermeasures, will now be discussed. It is appropriate, first, to examine the case where the towed object is located exactly on the axis of the aircraft, as seen by the threat. This can be easily resolved by means of an appropriate movement of the aircraft, or by the coordinated action of two

aircraft, each of which is equipped with towed objects according to the invention.

In this respect, the towed object can also be equipped with a simplified autonomous receiver which allows it to protect itself only from threats approaching from the rear. It can be of interest that similarly the towed object transmits, to the aircraft which tows it, information which may be chiefly in digital form.

Another variant would consist in carrying decoys on board the towed object, which decoys are capable of increasing the infrared emission so as to increase its credibility with respect to the threat using a twofold electromagnetic and infrared detection system.

.The practical use of the device of the invention can involve a division of tasks: in fact, the jammers inside the towing aircraft are sufficient for neutralizing radars which do not intervene directly in the guiding of weapons. In contrast, it will be necessary to put the towed object into operation for radars of threats which are guided by homing heads or radars assigned to gun or to missile aiming or guidance.

It should be noted in this respect that the electronic countermeasures system of the aircraft, by definition, knows the position of the transmitter which it tows and that it also knows, at least approximately, the direction of the threat.

The jamming signal which it sends to the towed object can be optimized, even for sophisticated signals such as so-called "Doppler pulse" signals or coded signals of the "chirp" type.

Of course, a plurality of threats can be jammed simultaneously, the towed transmitter having a very wide band and being amply dimensioned with respect to power.

The bifilary digital link installed between the aircraft and the towed object ensures not only the control of transmission in front and behind, but also gain control and

direction controls, and a testing facility.

Another advantage of the invention is that, because of its distance from the aircraft, the transmitter is to a great extent decoupled from the principal receiver RP incorporated in the aircraft, by the well-known laws of propagation. The reception and transmission can thus be effected simultaneously. A reduction of the transmitted power can possibly be envisaged by controlling the digital link for very weak incident signals.

As already mentioned, the dissipation of heat generated in the interior of the object R can be effected by means of heat exchange with the outer surface of the towed jammer. There is little difference between the temperature of this outer surface and the so-called athermanous temperature with respect to aerodynamics. In order to improve the reliability of operation and reduce the cost of the optoelectronic components, these components may be cooled by means of the Peltier effect, as already mentioned, since there is in these components little energy to be discharged. The travelling-wave tubes, for their part, do not require a specific cooling.

Finally, it was proposed above, with respect to Figures 4 and 5, to transmit the jamming signal in two optical fibres, taking into account the wide band occupied by the latter.

An alternative solution consists in conveying the two signals along the same optical fibre, for example, by using laser diodes operating at two frequencies which are sufficiently different from one another.

Another variant consists in transiting the logic signals by means of optical fibres.

CLAIMS

1. An electromagnetic countermeasures method for aircraft, wherein an auxiliary towed jamming device is connected at least temporarily with an aircraft; a selected jamming signal is transmitted to said auxiliary device; and said selected jamming signal is transmitted by means of said auxiliary device.

2. A method according to claim 1, wherein said auxiliary device is supplied with electric power by means of lines which are likewise connected to the towing cable.

3. A method according to claim 2, wherein said power supply is effected with high-voltage and high-frequency.

4. A method according to any one of claims 1 to 3, wherein bidirectional digital line connections are likewise connected with said towing cable.

5. A method according to any one of the preceding claims, wherein the primary reception of the incident electromagnetic signals and the processing of the jamming signal are effected on board said aircraft, whereas said auxiliary device has the role of transmitting the thus-obtained jamming signal.

6. An electromagnetic countermeasures device for aircraft, comprising a towed auxiliary device which can be deployed from the aircraft, a towing cable equipped with at least one optical fibre, and means at the auxiliary device for the transmission of a jamming signal which is transmitted along said optical fibre.

7. A device according to claim 6, wherein the electric power supply of said auxiliary device is ensured from said aircraft by means of lines connected with said towing cable.

8. A device according to claim 7, wherein said power supply is effected with high voltage and at high frequency.

9. A device according to any one of claims 6 to 8, wherein, at the end of said towing cable nearer said auxiliary device, the optoelectronic receivers of said at least one

optical fibre are cooled.

10. A device according to claim 9, wherein said cooling uses the Peltier effect.

11. A device according to any one of claims 6 to 10, wherein digital line connections are connected with said towing cable.

12. A device according to claim 11, wherein said digital line connections at the towed object are arranged for commutation between two jamming transmission antennae arranged under respective radomes in the front and in the back of said auxiliary device.

13. A device according to one of claims 6 to 12, wherein said auxiliary device comprises a transmission amplifier consisting of travelling-wave tubes.

14. A device according to one of claims 6 to 13, and comprising two of said optical fibres connected with said towing cable for the transmission of the jamming signal according to two portions of the useful frequency spectrum.

15. An electronic countermeasures method substantially as hereinbefore described with reference to Figures 2 to 5 of the accompanying drawings.

16. An electronic countermeasures device constructed and adapted to operate substantially as hereinbefore described with reference to, and as illustrated in, Figures 2 to 5 of the accompanying drawings.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

14

Application number 9308923.3

Relevant Technical fields

(i) UK Cl (Edition L) H4D (DSC) H4L (LBJ) F3C (CAJ)

(ii) Int Cl (Edition 5) G01S and H03K

Search Examiner

KEN LONG

Databases (see over)

(i) UK Patent Office

(ii) NONE

Date of Search

17 JUNE 1993

Documents considered relevant following a search in respect of claims 1 to 16

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	US 5,136,295 (BOEING) (see particularly column 1 lines 7 to 12, column 3 lines 17 to 43 and column 12 lines 39 to 68)	1,2, 5-7
X	US 4,808,999 (LORAL) (see particularly column 1 lines 6 to 8 and 41 to 62	1,5 & 6
X	EP 0,465,737 A1 (SANDERS) (see particularly column 1 lines 15 to 55)	1 & 4

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